Proceedings - 1999 RAIRE and AIRE Project Directors' Meeting

NSF strives to enable innovative activities, which foster integrated environments for research and education, in which education is infused with the joy of discovery and research is informed by the needs of the learning process. NSF has used many competitions and programs to pursue this goal, including the 1997 NSF RAIRE (Recognition Awards for Integrating Research and Education) competition and the 1998 NSF AIRE (Awards for Integrating Research and Education) competition.

NSF hosted the first RAIRE and AIRE Project Directors Meeting on June 24-25, 1999 at NSF Headquarters. The meeting was attended by investigators funded through the RAIRE and AIRE competitions as well as by those funded through other NSF programs, whose projects had significant activities designed to effectively integrate research and education. The meeting agenda was designed to allow participants to discuss and share their perceptions of best practices for integrating research and education (IRE) and the challenges both institutions and investigators face in pursuing IRE goals. The following are brief excerpts from the proceedings.

Key Factors Characteristic of Successful Programs that Integrate Research and Education

Facilitators: *Martha Abshar – Duke University(Engineering Research Center)*
Mary Allen – Wellesley College (AIRE)
Chris Craney – Occidental College (AIRE)
Jim Siedow – Duke University (RAIRE)
Henry White – University of Missouri – Columbia (RAIRE)
Jim Williams – Carnegie Mellon University (Engineering Research Center)

1. Strong Institutional Support – A commitment to the importance of integrating research and education must be expressed in an institution's vision. Institutional leaders must enable realization of the vision by providing critical administrative, philosophical and financial support to faculty and students engaged in these endeavors. Recognizing that successful implementation of IRE strategies requires critical resources, e.g. time, funding, change in culture and reforms in administrative policies, institutions must develop a wide-ranging reward system that recognizes the contributions of faculty who pursue IRE goals. This may require a considerable revision of current tenure policies.

2. Commitment of Faculty and Program Coordinators - Faculty members are crucial for the successful implementation of IRE goals, and must be fully committed to the concept. New faculty must be encouraged, mentored and assisted to develop effective, innovative strategies to integrate research and education. All involved must realize that IRE is not a "steady- state" and that opportunities to more effectively integrate research and education have to be continuously pursued. An environment promoting both intellectual and experiential growth must be created to invigorate student learning and participation.

3. Collaborations - Collaborative arrangements among students, faculty, and researchers across disciplines, institutions and industry offer participants a plethora of research and educational opportunities that would otherwise be limited or non-

existent if the traditional means for conducting research and learning continue. Curriculum-based activities should be built around departments and not individual faculty.

4. Integration of Faculty and Student Research - Colleges and Universities must encourage faculty to use their own research programs to mentor undergraduates. Means for such encouragement can include: providing ample stipends (and related arrangements such as housing) to allow students to spend full summers as research assistants; funding supply-and-expense grants for undergraduate researchers; returning to the PI overhead collected on the salary/stipend of an undergraduate assistant paid from the PI's externally funded grant; announcing preference, in the awarding of institutionally-funded grants, for research proposals that include well-defined roles and funding for undergraduate researchers in the project; instituting a system of course credit that integrates undergraduate research into the curricula of all majors; mounting an effective system of advisement to interest undergraduates in research and introduce them to appropriate faculty; including supervision of undergraduate theses as a category in annual faculty evaluations; giving official recognition (from the President or Provost) to faculty whose undergraduate researchers achieve professional presentation, publication and prizes; creating institution-wide prizes for faculty excellence in IRE.

5. Student Focus – For students interested in pursuing science, mathematics, engineering, and technology careers, faculty advisors and mentors must ensure that students have the requisite academic training enabling them to pursue their career goals. In tailoring opportunities to be developed for and offered to students, faculty must take into consideration the cognitive development of their students, must be aware of the diverse academic and cultural backgrounds of their students and be able to accurately gauge the students' ability to explore IRE opportunities with the degree of independence necessary in such endeavors. Follow-up is crucial to ensure students with an interest in scientific and/or technical careers are continuously encouraged to pursue these goals.

6. Undergraduate Research Opportunities – Research experiences must be made available to as many undergraduates as possible as early as freshman year. Students should be actively engaged in research that stimulates curiosity and develops a passion for discovery. Undergraduate scholars should be encouraged to develop proposals for projects in which they receive small institutional–sponsored awards (e.g. $500). Undergraduate Research Symposia may be used to provide a forum where students are intellectually stimulated, engaged in discussion and disseminate knowledge amongst their peers.

7. Inquiry Based Learning - Students should be exposed to inquiry based learning throughout the curriculum. Problem – Based Learning (PBL) provides one model that can be used or adapted for most science and engineering subjects. Faculty who are willing to try novel active learning formats should receive support from their home institutions to attend and/or sponsor workshops such as those available on PBL. Teaching circles provide an interactive learning vehicle that encourages interdisciplinary learning and exchange of information; active (reasoning) learning versus passive (factual) learning. Information technology is also proving to be an excellent tool to facilitate student learning.

8. External Support - Sustaining IRE activities within institutions requires substantial internal resource investments which should be coupled with investments from

external sources. Program coordinators must actively seek opportunities that provide support for instrumentation acquisitions, mini-research projects, internships, and professional society support. External support is crucial in implementing and sustaining long-term activities and requires broadening funding solicitations to include private foundations and potential industrial partners, as well as local, state and federal government agencies.

9. Professional Societies - Professional Societies must assume an active role in promoting IRE.

10. Assessment – Evaluation and assessment tools must be developed and employed to ensure program effectiveness at the classroom and pedagogy levels. Many institutions lack effective assessment and evaluation instruments and where they exist, they can be difficult to use. The challenge for those charged with conducting IRE activities is to identify the desired student outcomes and to determine the effectiveness of activities in realizing such outcomes.

11. Teacher Preparation – Science faculty should be involved in the preparation of future K-12 teachers. Future K-12 teachers should have research experiences to understand scientific methods and inquiry as they prepare to be teachers of science.

Integrating Undergraduate and Graduate Education

Facilitators: Wendy Katkin – State University of New York at Stony Brook (RAIRE)
Charles DeLisi – Boston University (Integration of Graduation Education and Research Training)

To effectively integrate research and education at the undergraduate and graduate levels, institutions must create an environment to better integrate the activities of undergraduate and graduate student research and education experiences. The nine items described below can facilitate the development of an environment and a culture, which promote and has the potential to successfully integrate undergraduate and graduation education.

1. Encourage Team Research. There are three criteria that must be met in the establishment of successful research teams: 1) Teams should be composed of both graduate and undergraduate students, 2) Teams should be diverse in representation and where appropriate, must involve students from various disciplines, and 3) Teams, once developed, should serve as catalysts to generate additional collaborations among faculty in different disciplines. Participants of IRE activities must maintain a focus on team goals, and the prerequisite and small steps required to achieving such goals.

2. Develop Innovative Courses. Early confidence-building courses or research experiences for students, particularly women and minorities, will bolster further study of science, mathematics and engineering disciplines, as well as improve retention in these fields. Institutions must ensure that faculty receive credit from appropriate departments for contributions to interdisciplinary programs.

3. Supplement Educational Experiences. Provide opportunities for graduate and undergraduate students to supplement and enhance their education by establishing partnerships with the private sector e.g. industrial rotations, or other appropriate organizations.

4. Strengthen Graduate Training. Develop mechanisms that will prepare graduate students to supervise research and enable students to teach in areas outside of their chosen discipline. Faculty must appreciate the "value added" in having doctoral students engage in research and teaching collaborations with other departments.

5. Improve Communication. Refine the channels of communication among all students both within and outside of their specialization. Formal communication training, as well as individual and team research, is important in the development and retention of students.

6. Preparation of the Next Generation of Faculty. Allow graduate students to gain experience in defining, designing, and implementing small research projects that can be conducted by groups of undergraduates. Providing graduate students with such opportunities will help prepare a new generation of faculty that is equipped to teach students.

7. Conduct of Science. It is imperative that students have an appreciation of how science is conducted. Graduate and undergraduate students must be exposed to the appropriate protocols and methodologies for conducting research.

8. Measure of Success. Institutions must develop and implement quantitative measures of success to determine whether initiatives should be continued and/or institutionalized. Program effectiveness cannot be assured if such standards are not in place. Appropriate mechanisms should be developed to scale up and institutionalize best practices.

9. Synergy Between Research and Classroom Learning. IRE programs can create and sustain synergy by introducing new approaches in the classroom as well as enabling students to apply classroom learning in a research setting.

Assessment and Evaluation

Facilitators: *Joan Bennett – University of Delaware (RAIRE)*
Sandra Gregerman – University of Michigan (RAIRE)
Christine Massey – University of Pennsylvania, Institute for Research In Cognitive Science (Science and Technology Center)
Elaine Seymour – University of Colorado

There is consensus among those who advocate the integration of research and education that assessment is critical in determining its effectiveness in producing high quality science and engineering scholars. Establishing an assessment tool can be challenging due to the many variables involved, such as learning styles, personalities, generation effects, available resources, and types of institutions. Those responsible for evaluation studies must develop instruments tailored to evaluate specific tasks and ascertain how the instrument can be used to enhance the effectiveness of the task. Evaluators must be mindful that different institutions have different problems and that no assessment or evaluation model is directly transferable, understanding that the specific needs of different institutions will require specific solutions. Nevertheless institutions that are similar can assist each other by establishing collaborative arrangements to develop evaluative tools and thereby share resources. Pooling resources to develop assessment strategies and tools can alleviate the burden of the high costs incurred in their development, the time necessary to secure additional funds, and the investment necessary to locate the expertise necessary to administer the evaluation.

There are many challenges associated with conducting a high quality evaluation. It is imperative to identify a central source of expertise, and develop strategies to involve faculty from particular disciplines with expertise to offer e.g. education and psychology. Assessment for continuous improvement should be the goal, transitioning from an assessment for accountability mindset. Questions should be directed towards assisting the evaluator determine the impact of undergraduate learning, whether inquiry-based learning is working and whether it is better than traditional methods. Other questions to be addressed might include: Is there a "best approach" for all students? All topics? Can students learn to adapt to pedagogy rather than pedagogy adapting to students? etc.

Evaluations should be student- centered, and should assist students in seeking self-knowledge and development, enhancing their growth experience in self-awareness and identification. Students should learn how to do research by asking good questions, approaching ill-structured problems with confidence, and being creative in the conduct of research. Results from evaluations can facilitate improvements for IRE activities if both faculty and students fully participate.

Educational Innovation

Facilitators: *Gregory Bothun – University of Oregon (RAIRE)*
Frances McMichael – Carnegie Mellon University (Combined Research and Curriculum Development)

Proponents of IRE concur that educational innovation is needed for IRE activities. Two examples of educational innovation are:

1. Development of robust simulations of interdisciplinary and multi-dimensional environmental problems where student learn the relation of outputs to inputs. Students will gain an understanding of scientific complexity and ambiguity.

2. Transformation of general education requirements into a more focussed and thematic structure.

Educational innovation is important to:

1. Reform courses to emphasize the understanding of science and not science facts; and to promote student collaborative work that centers around research.

Barriers to adoption of educational innovation include:

1. Limited resources available for core course curriculum reform

2. Service teaching does not lend itself to innovation.